EXHIBIT 4

United States Patent

Eglin

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[54] AIMING DEVICE FOR LIGHT WEAPONS PARTICULARLY FOR COMBATING MOVING AIR TARGETS

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[30] **Foreign Application Priority Data**

Dec. 20, 1968 Germany .....P 18 15 992.7

[52] **U.S. Cl.** .....**33/49 B**, 89/41 AA

[51] **Int. Cl.** **F41g 3/08**

[58] **Field of Search** .....33/49; 89/41 AA

[56] **References Cited**

UNITED STATES PATENTS

3,263,566 8/1966 Eglin et al. .....33/49 B

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[57] **ABSTRACT**

A device for determining lead values, appears with the lead directions being represented as apparent flight directions, in the viewing field of a telescope or reflex sight, in the form of radial line markings. The radial line markings are associated with at least one lead curve which is movable relative to the line markings and is driven only as a function of the elevation aiming movement of the weapon. Two lead curves are provided, each assigned to a respective different target speed. The lead curve assigned to the faster target speed is driven in accordance with the sine function of the elevation angle of the weapon, and the lead curve assigned to the slower target speed is driven in accordance with the cosine function of the elevation angle of the weapon. The radial line markings present lead markings formed by interruptions therein as well as by their inner ends adjacent the cross hairs of the viewing field.

8 Claims, 4 Drawing Figures

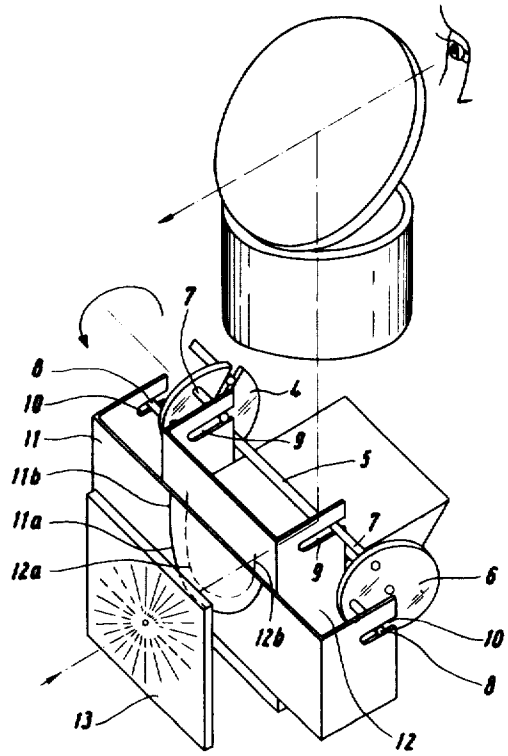

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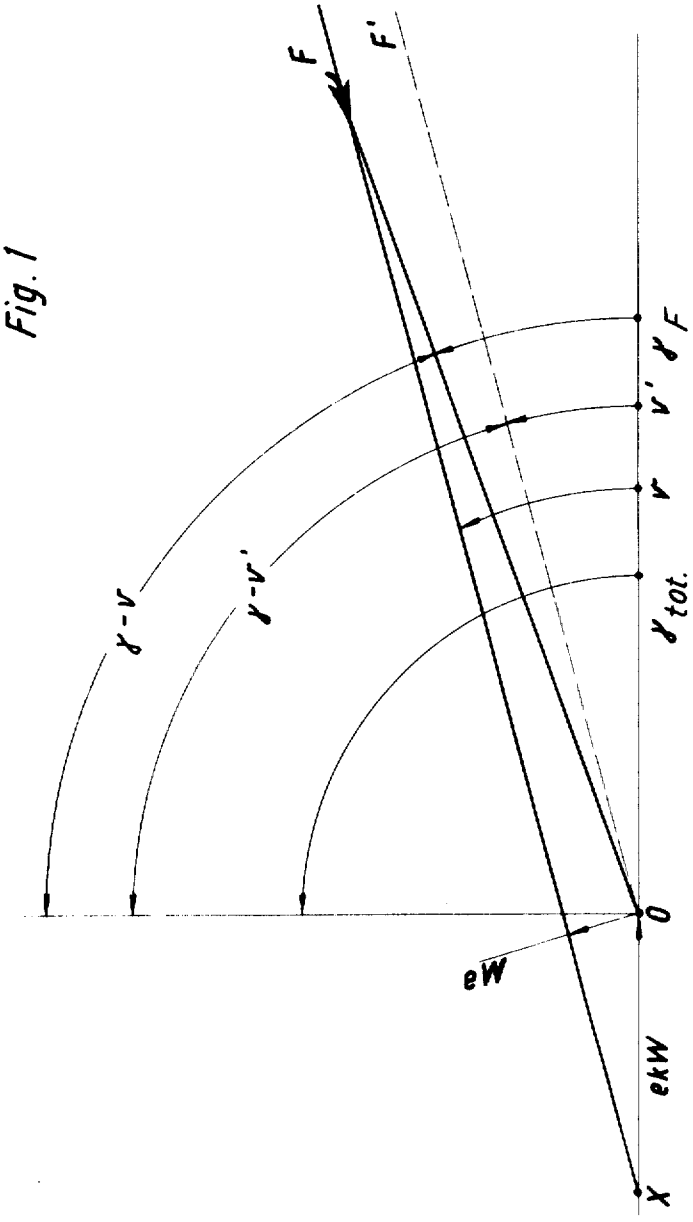
Fig. 1



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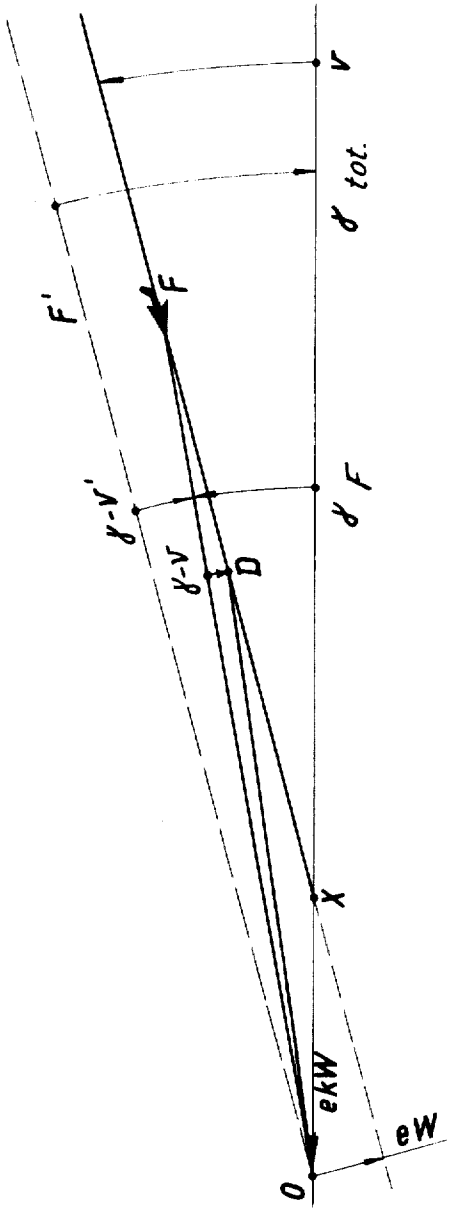

Fig. 2

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Fig. 3

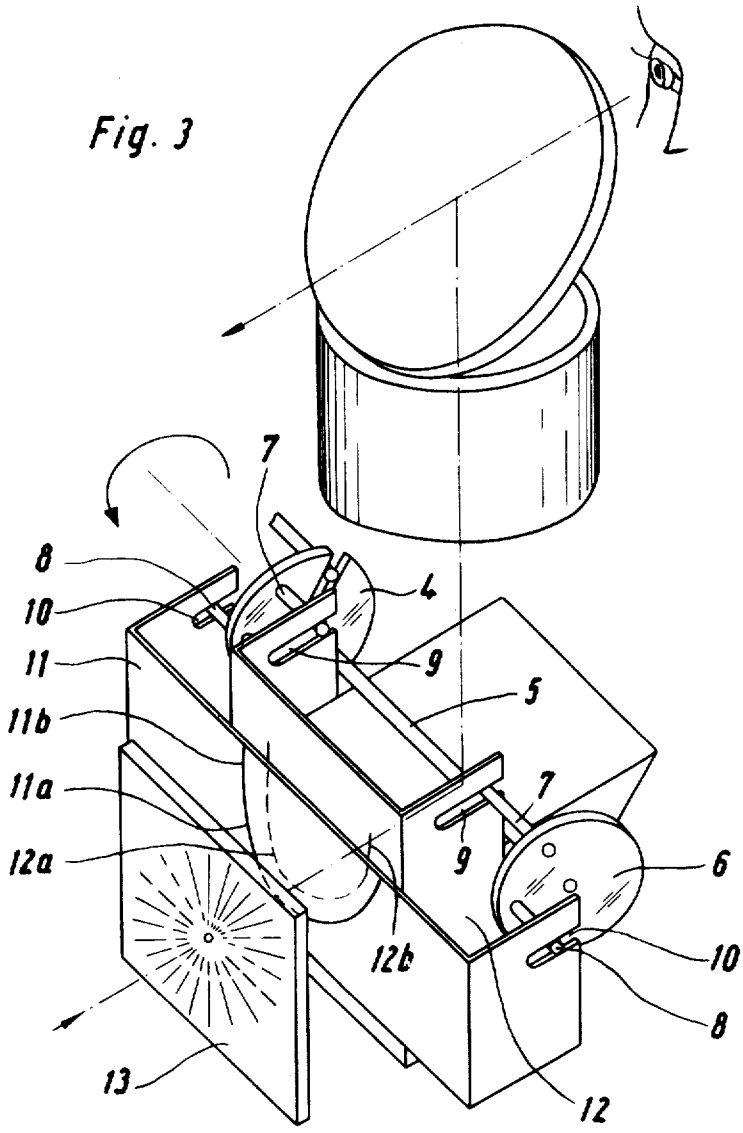

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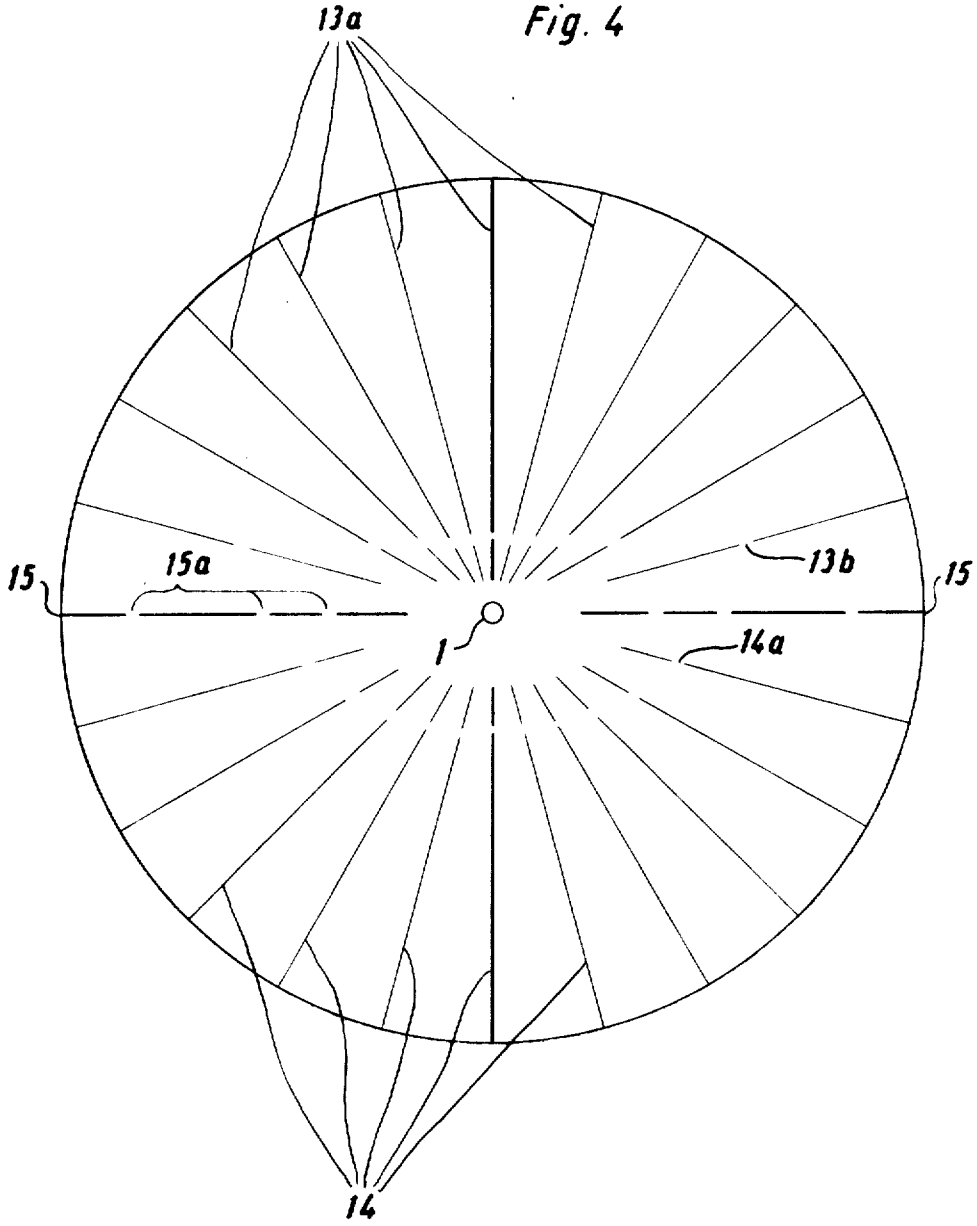
Fig. 4



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AIMING DEVICE FOR LIGHT WEAPONS PARTICULARLY FOR COMBATING MOVING AIR TARGETS

BACKGROUND OF THE INVENTION

The invention relates to an aiming device for light weapons, particularly for moving air targets, with a device for determining the lead values. The directions of the lead are represented as apparent flight directions in the viewing field of a telescope or reflex sight, and in the form of radial line markings, on a transparent plate, associated with at least one lead curve, on a transparent support, which is movable, relative to the line markings, and drivable only as a function of the elevation aiming movement of the weapon.

In such an aiming device, such as described in detail in U.S. Pat. No. 3,263,566, it is possible to take into consideration the change in the course of the lead values, resulting from an inclined trajectory of the target to be combated, by a corresponding manual modification of the zero setting of the elevation angle between the gun barrel and the sight. By this is meant a modification between the elevation angle, as fed by the weapon into the sight, and the elevation angle after moving the lead curve in the sight.

Such a readjustment is disadvantageous, inasmuch as it requires additional manipulations and inasmuch as it is not quite satisfactory with respect to the lead values furnished.

Thus, when inclined trajectories, such as resulting from the attack of an aircraft against objects by diving, are studied a little closer, it will be found that the course of the lead values depends directly upon the emplacement of the gun or weapon relative to the target at which the aircraft is aiming.

For example, if the gun is located in front of, or laterally in front of, the target at which the aircraft is aiming, the elevation angle of the weapon increases in following the target, and the lead curve moves downwardly. In such cases, the elevation angle value of the weapon, resulting from the moment of target apprehension to the attainment of the maximum value possible, is the one in question for moving the lead curve disc. On the other hand, the elevation angle, resulting from the apprehension of the target, is composed of the angle of flight inclination and an elevation angle of the weapon indispensable for prefeeding the curve. However, the readjustment mentioned above takes into consideration only the angle of flight inclination, and not the value required for prefeeding the curve.

If, instead of the gun being located in front of the target at which the aircraft is aiming, the gun is located behind, or laterally behind, this target, the elevation angle of the weapon decreases after apprehension of the target, and the corresponding lead curve disc is moved upwardly. Since the air target pulls up several hundred meters ahead of the land target, thus leaving the straight trajectory, there results, for the prefeeding of the lead curve, a relatively small elevation aiming motion, so that the motion of the lead curve disc is hardly noticeable.

Analogous cases result from the deployment against obliquely ascending and obliquely descending helicopters, in the tracking of which the lead values also change but very little, due to the relatively slow speeds.

SUMMARY OF THE INVENTION

This invention relates to aiming apparatus for light weapons, particularly for combating moving air targets, and, more particularly, to an improved aiming apparatus which can be used successfully for tracking not only for aircraft moving along inclined flight paths but also for combating or tracking slow-moving targets, such as helicopters, which move up and down in zigzag flight.

An objective of the invention is to design aiming devices of the kind under discussion in an improved manner so that the above readjustment of the elevation angle need no longer be made for inclined flight paths of an airborne target being tracked.

Using, as a basis, an aiming device of the type described above, the present invention solves the problem involved by making the lead curve support drivable in accordance with the cosine function of the elevation angle of the weapon, and by providing that the lateral ends of the lead curve extend vertically in a manner such that lead values are obtainable at any possible elevation angle of the weapon, as well as when the moving air targets fly past the weapon, even at the critical point.

In a preferred embodiment of the invention, the aiming device is characterized by at least two lead curves, on supports, each assigned to a different target speed. The lead curve assigned to the greater target speed is drivable in accordance with the sine function, and the lead curve assigned to the slower target speed is drivable in accordance with the cosine function, of the elevation angle of the weapon.

The lead curve moving downwardly during aiming motion of the weapon when the flight path of the airborne target is inclined, as when the weapon is in front of or laterally in front of the land object, is driven in accordance with the cosine function of the elevation angle of the weapon. Thereby, upon target apprehension or detection, this lead curve moves by such small values that no lead values are yet developed therefrom, or only lead values small enough to be of no practical significance. Thus, the hitherto required manual readjustment of the elevation angle is obviated, which leads to a correspondingly simpler operation of the aiming device. Another advantage is that this lead curve disc furnishes, in addition, lead values for slow, horizontally flying air targets, such as helicopters.

In the preferred embodiment of the invention including at least two curve carrying transparent supports or discs, the other disc is driven, as heretofore, in accordance with the sine function of the elevation angle, and, therefore, is excellently suited, in a known manner, for combating horizontally flying and preferably fast-moving air targets.

Bearing in mind that a movement of the lead curve disc is not necessary, because of the very small elevation aiming movements of the weapon, resulting from inclined flight paths when the gun is located behind, or laterally behind, the land-based object, in accordance with another feature of the invention, the radial line markings display lead markings formed by interruptions therein, as well as lead markings formed by the inner ends by the radial line markings adjacent crosshairs in the viewing field. This makes it possible to combat, with one and the same aiming device, very fast-moving and very slow-moving air targets, such as helicopters flying in a so-called zig-zag pattern. Lead markings of this type do not interfere with the sighting in the viewing field of the aimer, nor do they blur. If these lead markings were in the form of complete curves or complete ellipses, and if they appeared in the immediate vicinity of the crosshairs or sighting center of the viewing field, due to the small lead values in question, the lead curves thus developing would intersect the vertical radial lines so that they could be confused with the crosshairs and cause lead errors in magnitude and direction.

The line disc, according to the invention, does not have this disadvantage, because, in the invention line disc, the lead markings are formed by the distance between the crosshairs and the inner ends of the radial lines, as well as by the interruptions in these radial lines. The inner ends of the radial lines which, as known, are closest to the crosshairs and are thus closest to the theoretical point of impact, represent a first target distance, and the interruptions of the radial lines represent a second target distance. In other words, the inner ends of the radial line markings correspond to slow target speeds while the interruptions are correlated with faster target speeds.

An object of the invention is to provide an aiming device of the type mentioned in which readjustment of the elevation angle, for inclined flight paths, is no longer necessary,

Another object of the invention is to provide such an aiming device which can be employed for combating slow-moving targets, such as helicopters, which move up and down in zig-zag flight.

A further object of the invention is to provide such an aiming device in which the lead curve support or disk is drivable in accordance with the cosine function of the elevation angle of the weapon.

Another object of the invention is to provide such an aiming device in which the lateral ends of the lead curve extend vertically in such a manner that lead values are obtainable at any possible elevation angle.

A further object of the invention is to provide such an aiming device including at least two lead curves assigned to respective different target speeds.

Another object of the invention is to provide such an aiming device in which the lead curve assigned to the greater target speed is drivable in accordance with the sine function, and the lead curve assigned to the slower target speed is drivable in accordance with the cosine function, of the elevation angle of the weapon.

A further object of the invention is to provide such an aiming device in which the radial line markings display lead markings formed by interruptions therein as well as by the inner ends of the radial line markings adjacent the crosshairs of the viewing field.

For an understanding of the principles of the invention, reference is made to the following description of a typical embodiment thereof as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a graphical illustration of the geometric relationships and the course of the elevation aiming motions of the weapon when the weapon, having the aiming device of the invention, is located in front of, or laterally in front of, the object to be protected;

FIG. 2 is a view similar to FIG. 1 showing the geometric relations and the course of the elevation aiming movements of the weapon when the latter is located behind, or laterally behind, the object to be protected;

FIG. 3 is a perspective view of the driving device for the discs supporting the lead curves of an aiming device embodying the invention; and

FIG. 4 is a front elevation view of a line plate for an aiming device embodying the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

To facilitate an understanding of the invention, the inclined flight path of the airborne targets to be combated will first be examined more closely. As indicated in FIG. 1, a gun O is placed at a distance *ek*W in front of an object X being approached by an airborne target F at an angle of inclination V. For target apprehension or tracking, the gun barrel, which has not been illustrated, is turned in the direction O–F, with a resultant elevation angle γ–F. When pursuing the airborne target F on its flight path, F–X, the gun barrel executes another elevation aiming movement, namely, γ–V. If the airborne target is pursued to the critical point *e*W, the gun barrel can perform an elevation aiming motion totaling γ–tot.

If a lead curve disc, provided for inclined flight paths, is shifted in accordance with the sine function of the elevation angle of the gun, it would furnish, upon target tracking i.e., after the elevation angle has passed through the range γ–F, too great a lead, and the lead error would be proportional to the angle of inclination V′, because the elevation angle, required for moving the lead curve disc must begin only from the straight line O–F′ which extends parallel to the flight path F–X. Therefore, the angle V′ has been subtracted from the elevation angle γ–tot or γ–F, by a manually operable readjustment, so that there remained, for the further motion of the lead curve disc, only the angle γ–V′.

Nevertheless, when, as will be described hereinafter in detail, the lead curve disc is driven in accordance with the cosine function of the elevation angle of the weapon, the motion of the lead curve disc resulting in target apprehension, i.e., at γ–F, is so small that the value V′ does not appear at all.

In the case illustrated in FIG. 2, the gun O is placed at a distance *ek*W behind the object X which again is approached by an airborne target F at an angle of inclination V. However, as different from the example shown in FIG. 1, the airborne target F does not fly to the point *e*W, but veers from the straight flight path F–X at point D.

The geometric relations are similar to those in FIG. 1, but it has to be borne in mind that the parallel O–F′, from which the theoretical elevation angle of the weapon should emanate, no longer lies below the flight path F–X but is now above the flight path F–X.

However, starting from reality, the value of the elevation angle γ–F is present in the sighting device at the moment of target apprehension, when the barrel of the weapon points in the direction O–F. Accordingly, the elevation aiming motion resulting during tracking of the target from F to V amounts to only γ–V as yet. The lead curve disc movement resulting therefrom is so small as to be of no practical significance.

Now, assuming a constant mean value for the elevation aiming movement γ–V′ of the weapon, theoretically to be considered, and calculating the lead values as a function of a mean inclined flight path, lead markings can be plotted on the line disc, and these correspond to that flight path and also furnish still usable lead values even for dropping helicopters and fast horizontally flying airborne targets underflying the weapon.

Aiming apparatus meeting the above-described contingencies will now be described in connection with FIG. 3. Referring to FIG. 3, the respective elevation angles assumed by the barrel of a weapon, which has not been shown, are transmitted, by a clutch which also has not been shown, to discs 4 and 6 mounted on a shaft 5.

Discs 4 and 6 support respective pins 7 and 8, which are mutually displaced by 90°, and which engage respective slots 9 and 10 of respective transparent lead curve discs 11 and 12 which are mounted so as to be movable and interchangeable. Lead curve discs 11 and 12 display or present respective lead curves 11*a* and 12*a*. The discs are mounted and movable in a manner such that one of the two discs, for example the disc 11, is driven in accordance with the sine function, and the other disc, for example the disc 12, is driven in accordance with the cosine function, of the elevation angle of the weapon.

The design or calculation of the cosine transmission follows from the assumption of a mean flight path inclination for which lead values can be calculated in advance, taking into consideration also the target speed and the ballistics of the weapon. In this arrangement, disc 11, driven in accordance with the sine function of the angle of elevation, is suited for fast, horizontally flying airborne targets, and disc 12, driven in accordance with the cosine function of the angle of elevation, is suited for slow, horizontally flying airborne targets and for fast, airborne targets approaching objects to be protected along an inclined flight path. If follows, from the explanations relating to FIGS. 1 and 3, therefore, that a readjustment of the elevation angle is no longer necessary with the arrangement of the invention.

Since the upper areas of lead curves 11*a* and 12*a* are now superfluous, these curves are so shaped that their respective ends 11*b* and 12*b* extend vertically. By virtue of this measure, the lead curves always furnish a lead value at any elevation angle, even at the critical point where the apparent flight direction, in pass-by flights, always reaches 90°.

Taking into consideration the conditions prevailing when flights paths according to FIG. 2 are involved, FIG. 4 represents a line transparent disc or plate 13 which is located, as shown in FIG. 3, in front of the lead curve discs 11 and 12. In the line disc 13 shown in FIG. 4, the spacings of the inner ends of the radial lines 13*a* and the interruptions in these radial lines, relative to the crosshairs 1, are chosen so that they create lead values for certain flights and air targets without resulting in a sighting image which is blurred or which interferes with the field of view.

The lead markings formed by the inner ends of radial lines **13***a* and their interruptions **13***b* are suited, for example, for combating air targets in whose tracking the elevation angle of the weapon decreases. This occurs, for example, in diving attacks against objects located in front of the gun emplacement, with helicopters in dropping flight, with target flights taking place below the trunnion level of the weapon, and with similar flight paths.

The lead markings formed by the inner ends of the radial lines **14***a*, and their interruptions **14***b*, are suited, for example, for combating air targets which are in rising flight, for example helicopters.

The lead markings formed by the inner ends of the horizontal lines **15**, and their interruptions **15***a*, are suited for combating airborne targets in tracking which the weapon barrel performs no changes in elevation.

It should also be pointed out, in this connection, that basically, for example, the inner ends of the radial lines **13***a* and **14***a*, as well their respective interruptions **13***b* and **14***b*, can be laid out or designed for various target speeds, whereas those of the horizontal radial lines **15** can correspond to various target distances but to only one target speed.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the principles of the invention, it should be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In aiming apparatus, for light weapons, particularly for combating moving air targets, and of the type including a device for determining lead values, with the lead directions being represented, in the viewing field of a telescope or reflex sight, as apparent flight directions in the form of radial line markings on a transparent plate, with the radial line markings including a pair of radial line markings extending horizontally in opposite directions to form a horizontal diametric line marking, the radial line markings being associated with at least one lead curve on a respective transparent support which is movable downwardly relative to the line markings, and means driving each transparent support as a function of the elevation aiming movements of the weapon; the improvement comprising said means driving at least one lead curve disk in accordance with the cosine function of the elevation angle of the weapon; each lead curve being curved downwardly from the horizontal with its curved portion terminating at points on a horizontal line whose midpoint is aligned vertically with the center of said diametric line marking; the lateral ends of said lead curve extending vertically upwardly from said points on said horizontal line; whereby lead values are obtainable at every possible elevation angle of the weapon, as well as in pass-by flights of the moving air target, even at the critical point.

2. In aiming apparatus for light weapons, the improvement claimed in claim **1**, including at least two lead curve supports each corresponding to a respective different target speed; the lead curve corresponding to the faster target speed being driven in accordance with the sine function, and the lead curve corresponding to the slower target speed being driven in accordance with the cosine function, of the elevation angle of the vehicle.

3. In aiming apparatus for light weapons, the improvement claimed in claim **1**, in which said radial line markings have lead markings formed by interruptions therein.

4. In aiming apparatus for light weapons, the improvement claimed in claim **1**, in which the inner ends of said radial line markings, facing crosshairs in said viewing field, are spaced from said crosshairs to present lead markings.

5. In aiming apparatus for light weapons, the improvement claimed in claim **2**, in which said radial line markings have lead markings formed by interruptions therein.

6. In aiming apparatus for light weapons, the improvement claimed in claim **2**, in which the inner ends of said radial line markings, facing crosshairs in said viewing field, are spaced from said crosshairs to present lead markings.

7. In aiming apparatus for light weapons, the improvement claimed in claim **1**, including means mounting each transparent support for movement and interchange.

8. In aiming apparatus for light weapons, the improvement claimed in claim **2**, including means mounting each transparent support for movement and interchange.

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